US Department of Transportation
Federal Aviation Administration

Advisory Circular

JUL 15 1994

DRAFT

Subject:	UNMANNED AIR VEHICLE DESIGN CRITERIA	Date: / Initiated by:	ATP-200	AC No: / Change:	xx-xx

1. PURPOSE. This advisory circular (AC) provides information and guidance to the aviation community on design specifications for unmanned air vehicles (UAV(s)). The guidance provided within this AC pertains to the design of typical UAV elements such as flight control, electrical, communications/data link, navigational, propulsion, air vehicle control station, flight termination, and structures.

2. EFFECTIVE DATE. This AC becomes effective

3. RELATED FAR SECTIONS.

a. 14 Code of Federal Regulations (CFR) part 1, Definitions and abbreviations.

b. 14 CFR part 21, Certification procedures for products and parts.

c. 14 CFR part 23, Airworthiness standards: normal, utility, acrobatic, and commuter category airplanes.

d. 14 CFR part 27, Airworthiness standards: normal category rotorcraft.

e. 14 CFR part 33, Airworthiness standards: aircraft engines.

f. 14 CFR part 35, Airworthiness standards: propellers.

g. 14 CFR part 36, Noise standards: aircraft type and airworthiness certification.

h. 14 CFR part 39, Airworthiness directives.

i. 14 CFR part 43, Maintenance, preventive maintenance, rebuilding, and alteration.

FAA Form 1320-15 (4-82) Supersedes WA Form 1320-2

j. 14 CFR part 45, Identification and registration marking.

k. 14 CFR part 91, General operating and flight rules.

4. RELATED READING MATERIAL.

a. Joint Aviation Authorities (JAA) Joint Aviation Requirements for Very Light Aeroplanes (JAR-VLA).

b. JAA Joint Airworthiness Requirements for Sailplanes and Powered Sailplanes (JAR 22).

c. AC 21.17-3, Type Certification of Very Light Airplanes under FAR § 21.17(b), dated December 21, 1992.

d. AC 23-8A, Flight Test Guide for Certification of Part 23 Airplanes, dated February 9, 1989.

e. AC 23-11, Type Certification of Very Light Airplanes with Powerplants and Propellers Certified to Parts 33 and 35 of the Federal Aviation Regulations, dated December 2, 1992.

5. BACKGROUND.

a. Extensive experience has been gained with UAV(s) operated by the Department of Defense (DOD) in Special Use Airspace. However, because civilian use of UAV(s) in the National Airspace System (NAS) is limited, there is a lack of civilian experience in UAV operations and a lack of data relating to UAV use in non-DOD operations.

b. In its initial review of UAV design criteria and operations, the Federal Aviation Administration (FAA) has determined that UAV(s) are sufficiently different from normal category airplanes certificated under the provisions of part 21 and part 23 to be considered a "special class" of aircraft under § 21.17 of the Federal Aviation Regulations (FAR). This determination is consistent with the definition of "class" as found in § 1.1 of the FAR and used with respect to the certification of aircraft.

c. The prospect of significant market growth in civil UAV operations has prompted the FAA and the aerospace industry to establish suggested criteria for UAV design and operation. Those criteria are provided as suggested design guidelines only and they are not intended to dictate given design solutions to UAV manufacturers. Alternative design solutions meeting the intent of these criteria or more suitably adapted to the envisaged type of UAV application and category may also be found acceptable. Although these criteria are not regulatory, the FAA asserts that the voluntary adoption of these criteria by the segments of the aerospace industry involved in UAV design and operation should

ensure that appropriate safety levels are maintained and public trust in UAV operations is gained. Additionally, this gradual approach toward the implementation of design and operational criteria should promote the technological development of civil UAV design and operations without putting an unreasonable economic burden on the industry.

d. Some of the difficulties currently encountered in establishing a set of acceptable UAV design and operational criteria result from the wide variety of UAV sizes and UAV types envisioned for production and from the diversity of UAV operations. Some UAV design criteria may apply to all UAVs and some may be unique to certain types and classes of vehicles. Future UAV design and operational provisions should eventually accommodate virtually all classes of UAVs and all types of UAV use. The data collected and experience gained in future civil UAV operations should also provide the FAA and the aerospace industry with the expertise necessary to adequately determine the best methods of controlling and integrating this new activity into the NAS.

6. DEFINITIONS. The following terms have the meaning listed when used in this AC.

a. Air Vehicle Control Station. The flight control station used to operate the UAV(s) via remote control.

b. Autonomous Operation. A programmable, automated flight profile that does not require human intervention for normal operation.

c. Catastrophic Failure. Any failure that leads to loss of the UAV(s) and endangers people and/or property.

d. Critical Failure. Any failure that leads to UAV flight interruption or termination.

e. Critical System. A system or systems, the loss or malfunction of which, would lead to a critical failure.

f. External Pilot. A UAV operator who, in the absence of full automatic takeoff and landing systems, visually controls the UAV flight path, generally during takeoff and landing.

g. Flight Termination System. A controllable parachute or automatic preprogrammed course of action used to terminate flight in case of a critical failure.

h. Internal Pilot. A person who operates the UAV(s) from a site that provides direct contact with the UAV(s). This pilot normally operates the UAV(s) by means of commands sent to the UAV(s) by radio link. Vehicle status and navigation information

is received from the UAV(s) via radio link. This pilot also may operate the UAV(s) by a hardware and/or software system on board the UAV(s) capable of providing flight path control inputs to the vehicle based on real-time environmental, system health/status, or tasking inputs. This pilot is responsible for monitoring autonomous operations.

i. Propulsion System. A system comprised of those components necessary to ensure the safe propulsion of the UAV(s).

j. Unmanned Air Vehicle (UAV). A UAV is an aircraft capable of flight beyond visual line of sight under remote or autonomous control for civil (non-Department of Defense) purposes. A UAV is not operated for sport or hobby and does not transport passengers or crew.

7. DISCUSSION.

a. Safety Standard. UAV operations should be as safe as manned aircraft insofar as they should not present or create a hazard to persons or property in the air or on the ground greater than that created by manned aircraft of equivalent class or category.

b. Registration. The FAA envisions that some form of vehicle registry and identification eventually may be required to track the information required for UAV reliability and failure rates. Vehicle registry information would be coordinated through the FAA's Civil Aviation Registry Division (AVN-400).

c. Technical Issues and Related Criteria.

(1) Advisory Circular 21.17-3, which pertains to the type certification of very light airplanes, serves as a general basis for UAV structural design criteria.

(2) Fail-safe principles should govern the design of UAV systems. System independence and/or adequate redundancy and back-up features should provide for safe functioning of the UAV(s) in the event of a system failure.

(3) Any system design should provide for a failure detection apparatus (pre-flight and in-flight built-in-test) that will notify the UAV operator of a system failure. Adequate procedures for the safe operation of the UAV(s) following a system failure and procedures for the automatic recovery of the UAV(s) should be clearly defined. Potential human UAV operator errors should be considered by UAV designers and adequate provisions should be taken to minimize the effects of such errors. Additionally, an engineering analysis of any UAV design should be submitted to the responsible Aircraft Certification Service office to assist the FAA in the further review of UAV

design criteria. The following are considered critical system design criteria for UAV(s):

(i) RTCA DO 178B. All UAV system software verification and validation activities should be performed in accordance with RTCA DO 178B.

(ii) Flight Control System. The flight control system may include UAV operator controls, sensors, computers, and actuation parts necessary to control the UAV flight trajectory. The system should ensure adequate stability throughout the UAV's expected flight envelope. Any single failure of the flight control system should not significantly affect the operator's ability to control UAV recovery. Provisions for possible reversion to degraded modes of operation also should be incorporated into flight control system design. The UAV(s) should remain controllable in the event of a propulsion system failure.

(iii) Electrical System. The electrical system should provide sufficient power and endurance to ensure safe operations and recovery throughout all phases of flight. In the event of an emergency, the electrical system or emergency power supply should be of sufficient size to enable recovery at either the intended or a predetermined/alternate recovery area.

(iv) Communications System/Data Link. Approval for all frequencies used in UAV operations must be obtained from the Federal Communications Commission (FCC). The maximum range of the communication link should be determined and substantiated by the UAV operator. Any single failure of the communications system (uplink or downlink) should not affect normal control of the UAV(s). Uplinks/downlinks are sensitive to electromagnetic interference (EMI) and should be adequately protected from this hazard. Vehicle designs should incorporate provisions for a preplanned recovery of the UAV(s) in the event of a temporary or total loss of the communications system.

(v) Navigation System. The vehicle navigation system should meet the required navigation performance (RNP) standards for the airspace classification in which the operations are to be conducted. Navigation system designs should also consider the complexity and level of air traffic operations found in the airspace in which the UAV(s) will operate.

(vi) Propulsion System. All essential elements of the propulsion system, including the engine, engine controls, propeller, propeller components, and essential sensors, should meet documented reliability standards established by industry or U.S. specifications.

(vii) Air Vehicle Control Station.

(A) Manned aircraft cockpit features (e.g., control placement and ease of control column forces), do not have to be duplicated exactly. Station design should facilitate control of the UAV(s) by the internal pilot and provide for unambiguous operations and clear indications of UAV flight status. Design criteria should minimize the potential for human error. All "conventional" flight indications and warnings necessary to ensure safe control of the UAV flight path should be provided. In particular, the UAV internal pilot should be informed of any degraded mode of operations due to any failure, including cases in which there is an automatic switching to an alternate or degraded mode of operation. The control station should include a diagnostic and monitoring capability for the status of the vehicle. Real time, direct communications/surveillance, and data transmission capability should be provided in the absence of failure. For operations in controlled airspace, direct communications with the FAA controlling agency should be incorporated into the air vehicle control station system design.

(B) The minimum required number of UAV operators and provisions for related task sharing should be determined by mission requirements. If an external pilot used during the takeoff and landing phases of the flight receives flight parameter information via an intercommunication system from the air vehicle control station, the inner communications system between the operator and the control station should be as reliable as conventional flight instrumentation.

(viii) Flight Termination System. The UAV(s) should have a means of safely terminating flight of the vehicle in all phases of flight operations. The flight termination system should avoid the use of explosives to the maximum extent possible.

(ix) Aircraft Structure. The aircraft structure should be designed to withstand the maximum expected operational loads as determined by the intended operational flight envelope of the UAV(s). Aircraft structural design should meet the standards imposed by JAR-VLA or by part 23 or 27 of the FAR. Verification of structural static and dynamic strength and durability should be demonstrated by test and/or analysis.

d. Operational Safety Aspects.

(1) Operational approval, including mission profile aspects, should take into account the results of demonstrated compliance with the above design criteria. The following elements should be included in the vehicle to ensure safe operation of a UAV:

(i) A demonstrated means to comply with the equivalent level of safety afforded by the "see and avoid concept" applied to manned flight operations.

(ii) The minimum equipment required to operate in the desired class of airspace.

e. Data Collection.

(1) Detailed flight records should be maintained and provided to the responsible Aircraft Certification Service office upon request. This data will enable the FAA to determine the number, types, applications, and reliability of UAV(s). UAV operators should maintain a record of each flight. These records should be maintained by registration number (if applicable) and should include but should not be limited to the following information:

(i) Mission purpose

(ii) Payload type

(iii) Flight duration and altitude

(iv) Specific information on critical system failures.

8. ADDITIONAL GUIDANCE. Operators of UAV designs and operators of UAV(s) engaged in applications that, because of mission requirements or hazardous conditions, e.g., UAV(s) may be expendable, cannot meet the suggested design criteria and operational guidance specified in this AC should contact the nearest FAA Regional Office for further information and guidance.

9. COMMENTS INVITED. Comments regarding this publication should be directed to: